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DRAINAGE EVOLUTION ON THE YÜNNAN-TIBET FRONTIER*

By W. M. DAVIS

A recent article¹ on the drainage conditions in the region where the Salween, Mekong, and Yangtze are compressed within a space of 50 miles in their flow southward from the Tibetan Plateau is a bold, not to say a venturesome application of deductive geomorphology in an effort to give explanatory description of the river courses in a lofty mountain region. The trend of the main ranges and valleys, as well as the strike of the nearly vertical rock structures, on the Yünnan-Tibet frontier is about north and south; but certain first-order tributary valleys, trending in part east or west, also turn to southward courses for part of their length; and, as it is assumed that such tributary valleys must originally have had wholly east or west transverse courses, an explanation for their southward turns is sought. The explanation proposed points out that the heavy rainfall comes with southwest winds and that the climatic control of vegetation on the higher slopes favors erosion on their windward aspects; it is therefore concluded that second-order tributaries, heading northward, would capture and divert the upstream parts of first-order tributaries farther north, and thus southward turns in the tributary drainage would be developed.

DISREGARD OF THE PRE-UPLIFT HISTORY OF THE REGION

The article is above characterized as bold, because it goes so much farther into deduction than is usual in British geographical essays; and for this the author deserves applause. The article is further characterized as venturesome, because the main postulate upon which its deductions are based is unwarranted; and for this the author ought to be cautioned. The unwarranted postulate is of a kind that is not infrequently met in the treatment of uplifted regions, in that it fails to take account of the form that the region had acquired by erosional processes before it was uplifted. It is here assumed without inquiry that "the natural course of every [first-order] tributary stream is [east or west] down the flank of the main divide"; that is that the mountain ranges, when first uplifted, had smooth lateral slopes, down which the first-order tributaries of the main rivers must have flowed in east or west consequent courses. In a word, the

* One of a series of "Notes on the Description of Land Forms," the latest of which appeared in the March *Geographical Review*, pp. 176-180, where a complete list is given of the preceding instalments.

¹ F. Kingdon Ward: The Hydrography of the Yünnan-Tibet Frontier, *Geogr. Journ.*, Vol. 52, 1918, pp. 288-299. [For photographs showing the topography of this region see *Geogr. Rev.*, Vol. 6, 1918, pp. 3, 12, 13, and 17.—EDIT. NOTE.]

pre-uplift history of the region is not considered; no account is taken of a possible cycle of erosion preceding the current cycle. Yet, inasmuch as the general structure of the region is nearly vertical, and inasmuch as the features of the Tibetan Plateau farther north give many indications of geologically modern uplift after a prolonged period of erosion at a lower stand, the most reasonable assumption that can be made as to the pre-uplift form of the region is that it consisted of broad old valleys, drained for the most part by long streams well adjusted to belts of the least resistant rocks, between subdued hills and ridges of the most resistant rocks crossed by short transverse streams. In view of this manifest possibility, a reasonable inference as to the form and drainage of the region directly after uplift is that the pre-uplift form and drainage still persisted in a general way, although new slopes and reversals of drainage may have been introduced here and there by uplifts of unequal measure.

PROBABILITY OF AN EARLIER CYCLE OF EROSION

Hence in this mountainous region, as in many others, the cycle of erosion that was introduced by the uplift to which the present altitude of the region is due is probably not a first cycle, previous to which no inquiry as to the development of river courses need be made. It is more reasonable to regard the erosion of the region as now in the early stages of a second cycle, at the beginning of which many river courses may have been inherited from a preceding cycle; and to regard the preceding cycle as having reached a far-advanced stage and as therefore having witnessed the adjustment of many streams to belts of weak structure. According to this view, a good number of the captures that are attributed by the author to the current cycle of erosion may well have taken place in the earlier cycle, and they may then have been determined more largely by variations of rock resistance than by the climatic factors which the author mentions as now operative. Unfortunately, the control exerted upon valley arrangement and form by resistant and weak structural belts is not recognized. Furthermore, the direction of the streams, and not the unlike resistance of structural belts, is taken to control valley width, as is seen in the statement that "as long as the stream follows the strike, the tendency is for it to cut a broad valley; when it cuts across the strike the tendency is for it to cut a narrow jagged-edged gorge." Again no account is taken of Campbell's principle, according to which the captures that have taken place during the current cycle may have been more largely influenced by a southward tilting of the region during its uplift—for the ranges decrease in height southward—rather than by climatic factors.

HANGING VALLEYS

Certain other items of interest may be noted. Waterfalls from hanging valleys are explained as due in some instances to the "overdeepening

of the main valley by water while the tributary valleys were filled by ice"—a discredited process—and in other instances to the deepening of a main valley as a result of increase in its river volume by capture farther upstream; but a special feature, namely an extreme narrowness of the main valley, which should accompany waterfalls from tributaries thus left suspended, is not mentioned; nor is reference clearly made to the much more effective cause for hanging-valley waterfalls in mountainous regions that is provided by the glacial overdeepening of the main valleys, although allusion is made to the broadening of certain valley heads by glacial action.

INCISED MEANDERS

One of the larger rivers turns "backwards and forwards on itself, loop lying against loop in a deep gorge through a mountain range." Such looping "would, of course, occasion no surprise in the case of a river meandering across a flood plain, but when it rushes through deep gorges the effect is staggering." A special explanation is therefore demanded; but in the explanation offered no account is taken of the very possible inheritance of the loop embryos from a meandering course developed during an earlier cycle of erosion, although such an explanation for the incised meanders of the Wye in western England, of the Seine in north-western France, of the Meuse through the Ardennes, and of the Mosel between the Hunsrück and the Eifel has long been current.

RECENT RENEWAL OF UPLIFT

The term "reversed" is used in a new and peculiar sense, in being applied to a tributary valley that, unlike ordinary valleys, which are narrow toward the head and broadly opened farther downstream, is broadly opened at its head and narrowed to a chasm at its confluence with the deeply incised valley of its trunk river. It is suggested that the broadening of the valley head may have been accomplished by glacial erosion, but nothing is said as to the possibility of a recent renewal of uplift as a cause of the deep incision of the lower valleys. Thus the author, who is very properly more interested in his Far East field of observation than in a review of pertinent literature, has repeated, in his discussion of these several items as well as in his main discussion, the unadvisable course of certain American observers, who fifty years ago were so overwhelmed by the novelties of our Far West that they described them without reference to the explanations and the terminology that had been previously suggested for similar though less striking features by stay-at-home students in older-settled regions.